Center Innovation Fund: SSC CIF

Nuclear Propulsion and Power Non-Nuclear Test Facility (NP2NTF): Preliminary Analysis and Feasibility Assessment

Completed Technology Project (2012 - 2013)

Project Introduction

Nuclear thermal propulsion (NTP) has been identified as a high NASA technology priority area by the National Research Council because nuclear thermal rockets (NTRs) are high-thrust propulsion systems with the potential for twice the specific impulse of the best liquid hydrogen (LH)/oxygen (LOX) chemical rockets. Multiple mission studies have shown that nuclear thermal rockets would enable rapid Mars crew transfer times and would require approximately half the propellant and about 60% of the launch mass that is required by chemical rocket technologies. NTP could serve as a near-term enabling technology to reduce human transit time and mission risk in space to Near-Earth Objects (NEOs) and Mars. One approach to overcome some of issues associated with working with nuclear propulsion technologies is to separate the development of core nuclear reactor subsystem elements from the development of the critical (and more numerous and diverse) downstream thermal management and control system elements. This project looked of the feasibility of this option.

Nuclear reactors, which power nuclear propulsion and power systems, and the nuclear radiation and residual radioactivity associated with these systems, impose significant constraints on technology and system development programs due to radiation safety, environmental contamination, and nuclear security concerns. There is a rigorous and time consuming process that is required for obtaining a nuclear reactor site license. Additionally, the development and testing of nuclear propulsion and power systems will have to rely on existing nuclear reactor research facilities, which only marginally meet NTP development needs. These facts, in combination with the increased security measures and standards required to safeguard nuclear material, limit the options available for developing new nuclear reactor research sites. To overcome nuclear facility infrastructure shortfalls and to mitigate the range of potential "nuclear concerns", one approach to develop required technologies to enable NTP capabilities, is to separate the development of core nuclear reactor subsystem elements from the development of the critical (and more numerous and diverse) downstream thermal management and control system elements. By separating them, the limited number of nuclear reactor research sites can concentrate on reactor system development without interference from the development of downstream elements. In this way, separate, non-nuclear test facilities can be designed and built to develop the other system elements required to convert the heat from a nuclear reactor to thrust, electricity, or other applicable components". Nuclear Propulsion and Power Non-Nuclear Test Facility (NP2NTF) represents a feasible extrapolation for extending Stennis Space Center's (SSC's) existing experience and expertise in designing and operating state-of-the-art, high flow rate, high pressure cryogenic piping systems for hydrogen and other propellants, as well as competencies in components, and instrumentation for special test equipment used in rocket propulsion testing are particularly relevant. SSC's experience in managing complex rocket propulsion test facilities and rigorous rocket propulsion test

Logo for Office of Chief Technologist

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Organizational Responsibility

Responsible Mission Directorate:

Space Technology Mission Directorate (STMD)

Lead Center / Facility:

Stennis Space Center (SSC)

Responsible Program:

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projects and engine qualification experience are key competencies that would be required for NP2NTF development and subsequent operation. SSC's extensive infrastructure that is in place, which is used for storing and utilizing large quantities of liquid hydrogen (LH) and liquid oxygen (LOX) is also a significant component required to the efficient and cost-effective operation of the NP2NTF. SSC's systems analysis and modeling capability, based on first-principles fluid physics and thermodynamics phenomena and routinely used to model, simulate, and predict the performance of SSC rocket propulsion test facilities, is also ideally suited for supporting NP2NFT design and facility characterization and performance prediction. By separating out the development testing of non-reactor core system elements, which comprise the bulk of nuclear propulsion and power systems, a NP2NTF would enable faster, less expensive, more efficient, and safer technology maturation and system development by eliminating the need to acquire and implement assets and infrastructure required for nuclear research. In this way, the development of core nuclear reactor system elements can be concentrated upon separately. SSC investigated these technologies, identified technology development options and performance requirements, and assessed feasibility.

Anticipated Benefits

Benefits to NASA funded missions most importantly include the specific point that the proposed NP2NTF would be designed to build upon previous modular, non-nuclear testing approaches, utilizing invested critical infrastructure in place, which SSC not only has historically supported, but still continues to support, to enable full-scale, integrated testing of key nuclear propulsion and power system elements. The NP2NTF modular approach will enable more focused technology maturation and more efficient, cost-effective, and timely development of critical systems, components, and materials operating downstream of the core nuclear reactor that would be used on a NTP. The NP2NTF would serve to enhance affordability and reduce risks inherent in development of nuclear propulsion and power systems.

Project Management

Program Director:
Michael R Lapointe

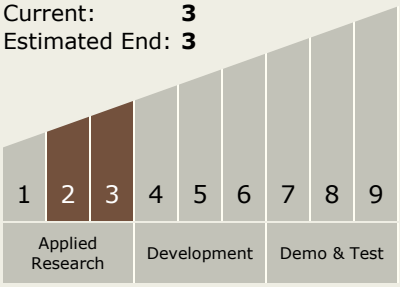
Program Manager:
Ramona E Travis

Project Manager:
David J Coote

Principal Investigator:
Harry M Ryan

Technology Maturity (TRL)

Start: **2**
Current: **3**
Estimated End: **3**



Technology Areas

Primary:

- TX01 Propulsion Systems
  - TX01.4 Advanced Propulsion
    - TX01.4.3 Nuclear Thermal Propulsion

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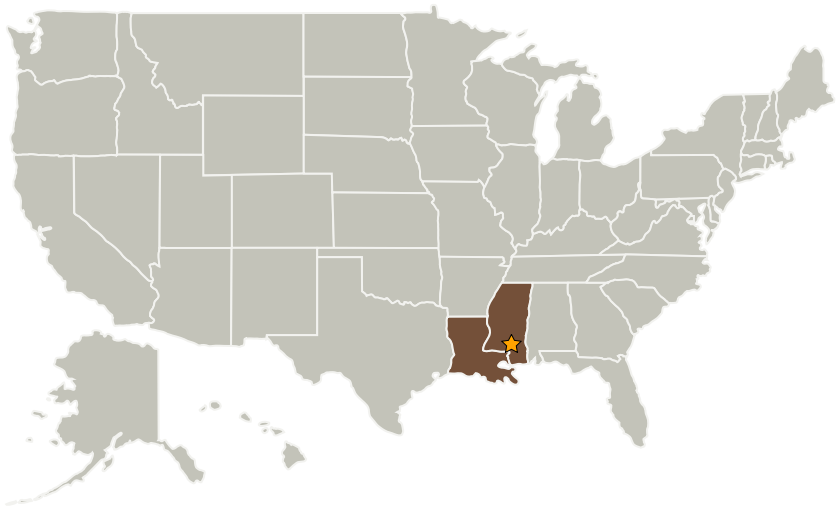
Primary U.S. Work Locations and Key Partners



Organizations Performing Work	Role	Type	Location
★Stennis Space Center(SSC)	Lead Organization	NASA Center	Stennis Space Center, Mississippi

Primary U.S. Work Locations	
Louisiana	Mississippi

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Images

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(https://techport.nasa.gov/image/3966)